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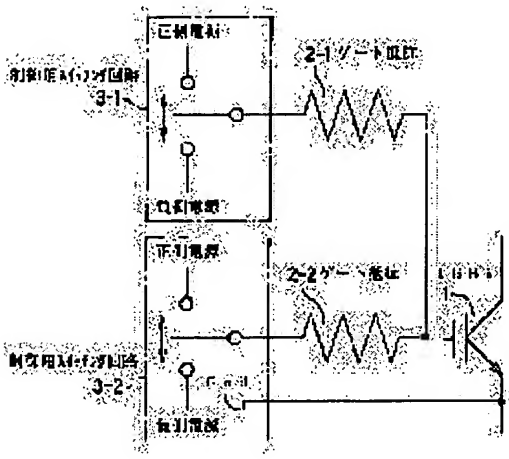
(54) GATE DRIVE CIRCUIT FOR VOLTAGE CONTROL-TYPE SWITCHING ELEMENT



(57)Abstract:
PROBLEM TO BE SOLVED: To provide the gate driving circuit of a voltage control-type switching element in a simple constitution which can be turned off with a small loss and a low surge voltage.
SOLUTION: The gate signal supplying circuit of an IGBT1 constituting a main circuit of a power converter is provided as a duplex constitution of two circuits. The gate signal supplying circuit is composed of a switching circuit for control 3-1 (3-2) for switching a gate voltage for turn-on and a gate voltage for turn-off, and a gate resistance 2-1 (2-2). At the time of turn-off, after an turn-off operation of one switching circuit for control 3-1, a turn-off operation of the other switching circuit for control 3-2 is executed after the lapse of a fixed time. Thus, a gate charge decreasing speed just after the start of a turn-off when the surge voltage is the maximum can be slowed, and the gate charge decreasing speed can be increased after a circulating diode has been turned on, and the main cause of the generation of a surge voltage is reduced.

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CLAIMS

[Claim(s)]
[Claim 1] The gate drive circuit of the armature-voltage control form switching element characterized by having prepared two or more gate signal supply circuits which supply alternatively the gate voltage for turn-ons, and the gate voltage for turn-ofves to the gate of an armature-voltage control form switching element through a switching circuit and gate resistance, having considered one as the actuation from the early stages of a turn-off, and considering others as the actuation after predetermined time on the occasion of a turn-off.
[Claim 2] In the gate drive circuit of the armature-voltage control form switching element which supplies alternatively the gate voltage for turn-ons, and the gate voltage for turn-ofves to the gate of an armature-voltage control form switching element through a switching circuit and gate resistance Prepare the initial specialized circuit of a turn-off which has a discharge way between the common terminal of a switching circuit, and Gnd level, and it faces at a turn-off. The gate drive circuit of the armature-voltage control form switching element characterized by operating only the initial specialized circuit of a turn-off first, and performing turn-off actuation of a switching circuit, and off actuation of the initial specialized circuit of a turn-off after predetermined time.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the gate drive circuit of armature-voltage control form switching elements (IGBT etc.), especially the surge voltage reduction technique at the time of a turn-off.
[0002]
[Description of the Prior Art] The surge voltage produced in case IGBT carries out a turn-off causes problems, such as a fall of service voltage, and an increment in switching loss, by the armature-voltage control form switching element, for example, the power converter using IGBT. The following cures are taken in in order to mitigate this surge voltage.
[0003] (A) The gate drive circuit which is equivalent to drawing 6 at this in the gate circumference circuit of .IGBT which makes a switching rate late is shown in drawing 7 , respectively. For IGBT and 2, as for the switching circuit for turn-on turn-off control, and 4, gate resistance and 3 are [one / the power source for turn-ons (electrical-potential-difference +Vcc) and 5] the power sources for turn-ofves (electrical potential difference - Vee) among drawing.

The switching circuit 3 for turn-on turn-off control is considered as the configuration it connected transistors TR1 and TR2 to the serial, and connected gate resistance 2 at the node, and connected +Vcc connection driver DR1 and -Vee connection driver DR2 to the base, respectively.

[0004] When the gate of IGBT1 is seen from the driver side to drive, it is visible as a capacitor (gate capacitance Cg shown in drawing 6). This means that the charge of a capacitor can be taken in and out quickly, if the resistance Rg of gate resistance 2 is made small. Therefore, if resistance Rg is made small, a switching rate will become quick, and conversely, if resistance Rg is enlarged, a switching rate will become slow. That is, gate resistance 2 can adjust the switching rate of IGBT1.

[0005] Since surge voltage is an electrical potential difference produced when IGBT1 carries out a turn-off quickly, it can stop surge voltage low enlarging gate resistance 2, i.e., by making a switching rate late.

[0006] (B) Generate . surge voltage which adds the snubber circuit which absorbs surge voltage with the energy stored in the suspension inductance (wiring inductance) of an IGBT main circuit. Therefore, if a snubber circuit is attached to IGBT and energy is absorbed to this snubber circuit, surge voltage can be stopped low. A typical snubber circuit is shown in drawing 8 and drawing 9 .

[0007] The snubber circuit 21 of drawing 8 is the configuration of having connected Diode Ds to resistance Rs' and juxtaposition, in order to make transitional equivalent resistance small, and it has connected to juxtaposition the snubber circuit 22 of the configuration and drawing 9 which connected Resistance Rs and Capacitor Cs to the serial at IGBT1.

[0008]

[Problem(s) to be Solved by the Invention] There are the following troubles in the above-mentioned cure.

[0009] Although surge voltage will fall if the trouble switching rate of (A) is made late, the time amount which switching takes becomes long. Although a problem shifts to cooling of a component since the increment in the switching time leads to the increment in the turn off power losses of a switching element (IGBT1), cooling of a component is important on a property and cannot make a switching rate slow recklessly.

[0010] When the trouble snubber circuit 21 (or 22) of (B) is attached, circuitry becomes complicated and leads to the increment in components mark and a man day. Moreover, since the switching rate of the latest IGBT is quite high-speed, the wiring inductance Ld which the snubber circuit 21 (22) itself shown in drawing 8 (drawing 9) has can be disregarded (there is a limitation in shortening the wire length of a snubber circuit), and there is a limitation in the effectiveness of a snubber circuit. Especially in IGBT, sufficient effectiveness is not expectable.

[0011] This invention aims at offering the gate drive circuit of the armature-voltage control form switching element which is easy circuitry and can carry out a turn-off in small loss and low surge voltage by having been made in view of the above-mentioned situation, and multiplexing a gate signal supply circuit.

[0012] Moreover, by ****ing the initial specialized circuit of a turn-off instead of duplex-izing of a gate signal supply circuit, this invention is comparatively easy circuitry and aims at offering the gate drive circuit of the armature-voltage control form switching element which can carry out a turn-off in small loss and low surge voltage.

[0013]

[Means for Solving the Problem] This invention prepares two or more gate signal supply circuits

which supply alternatively the gate voltage for turn-ons, and the gate voltage for turn-ofves to the gate of an armature-voltage control form switching element through a switching circuit and gate resistance, and is characterized by having considered one as the actuation from the early stages of a turn-off, and considering others as the actuation after predetermined time on the occasion of a turn-off.

[0014] Moreover, this invention is set in the gate drive circuit of the armature-voltage control form switching element which supplies alternatively the gate voltage for turn-ons, and the gate voltage for turn-ofves to the gate of an armature-voltage control form switching element through a switching circuit and gate resistance. Prepare the initial specialized circuit of a turn-off which has a discharge way between the common terminal of a switching circuit, and Gnd level, and it faces at a turn-off. Only the initial specialized circuit of a turn-off is operated first, and it is characterized by performing turn-off actuation of a switching circuit, and off actuation of the initial specialized circuit of a turn-off after predetermined time.

[0015]

[Embodiment of the Invention] One operation gestalt of this invention is shown in drawing 1 . Among drawing, in one, gate resistance, 3-1, and 3-2 are the switching circuits for turn-on turn-off control, and IGBT, 2-1, and 2-2 make two circuits the gate signal supply circuit of IGBT1.

[0016] Next, actuation is described. In carrying out the turn-off of IGBT1, it operates only one gate signal supply circuit 3-1, for example, switching circuit for control, side first. That is, the switching circuit 3-1 for control is switched to a negative side power source. In this condition, the gate signal supply circuit (the switching circuit 3-2 side for control) of another side is still a turn-on condition, and when the value of **Vg and gate resistance is set to Rg, an electrical-potential-difference condition comes to show supply voltage to drawing 2 (a). If this is seen from IGBT1, it will become the circuit and equivalence which are shown in drawing 2 (b). That is, 0 (V) joins the gate of IGBT1 through resistance of Rg/2.

[0017] For this reason, the number of gate signal supply circuits is one (refer to drawing 8), and the charge reduction rate in early stages of the gate of IGBT1 becomes equivalent (electrical-potential-difference one half, resistance one half) to the case where surge voltage is being reduced by what the value Rg of gate resistance is more greatly set up for. Therefore, an equivalent electrical potential difference also produces surge voltage. And after between a certain degree degree hours passes, the switching circuit 3-2 for control of another side also carries out actuation of a turn-off drive (after reflux diode etc. carries out a turn-on and the factor of surge voltage generating decreases). If it comes to carry out a turn-off drive in both the gate signal supply circuit, a charge reduction rate will become quick and a switching rate will become a high speed from the case of drawing 8 . Thereby, a switching rate is accelerable with equivalent surge voltage.

[0018] In addition, although the gate signal supply circuit was made into two circuits (duplex) with the above-mentioned operation gestalt, it can also multiplex in three or more circuits. In that case, if the number of circuits and the value of gate resistance are selected suitably, the gate charge reduction rate accommodation at the time of a fine turn-off is attained, and more effective switching operation (low switching loss and low surge voltage) can be expected.

[0019] Other operation gestalten of this invention are shown in drawing 3 . For IGBT and 2, as for the switching circuit for turn-on turn-off control, and 4, gate resistance and 3 are [one / the power source for turn-ons (electrical-potential-difference +Vcc) and 5] the power sources for turn-ofves (electrical potential difference - Vee) among drawing. The switching circuit 3 for turn-on turn-off control is considered as the configuration it connected transistors TR1 and TR2

to the serial, and connected gate resistance 2 at the node, and connected +Vcc connection driver DR1 and -Vee connection driver DR2 to the base, respectively. It is the initial specialized circuit of a turn-off, and the transistor TR3 turned on and turned off with this output constituted 6, the collector of a transistor TR3 is connected to gate resistance 2, and it has connected the emitter with the Gnd connection driver DR3 at the node (Gnd point) of the power source 4 for turn-ons, and the power source 5 for turn-ofves, respectively.

[0020] The initial specialized circuit 6 of a turn-off has the work which draws out a charge, when the potential of a driver output is higher than Gnd level. Moreover, it enables it to drive independently the Vcc connection driver DR1 and -Vee connection driver DR2 (in the usual driver, reversal actuation is carried out mutually).

[0021] Next, actuation is described. At the time of a turn-on, the initial specialized circuit 6 of a turn-off is not driven, but is similarly driven in the part of the Vcc connection driver DR1 like the usual gate driver. For this reason, the property at the time of a turn-on is equivalent to the usual driver.

[0022] At the time of a turn-off, after turning OFF the part of +Vcc connection driver DR1, the initial specialized circuit 6 of a turn-off is turned ON. In this condition, as a thick wire (an arrow head a is written together) shows to drawing 4 , the gate of IGBT1 is connected to Gnd level through gate resistance 2 and a transistor TR3. In the usual gate driver, in order to connect with -Vee power source from the beginning, this operation gestalt of the drawing force of the gate charge in this phase will be weaker, and it will switch it slowly. Surge voltage is reduced by this.

[0023] A turn-off progresses to some extent, and in the phase in which the generating factor of surge voltage decreased, as a thick wire (an arrow head b is written together) shows, the part of -Vee connection driver DR2 is turned ON at drawing 5 . The initial specialized circuit 6 of a turn-off is turned OFF at coincidence. Thereby, the switching rate after this becomes equivalent to the usual driver.

[0024] Therefore, although a switching rate becomes slow by this operation gestalt under the effect of the period of the initial specialized circuit 6 of a turn-off of operation even if it can reduce surge voltage when gate resistance 2 is made into the same value, surge voltage can make a smaller value the part which can make late the switching rate immediately after the switching produced most, and gate resistance 2. In Vcc=Vee, gate resistance 2 can be made the value of abbreviation one half, and the increment in the switching time by actuation of the initial specialized circuit 6 of a turn-off is fully compensated with it in that case by reduction in the period of subsequent -Vee connection driver DR2 of operation.

[0025]

[Effect of the Invention] Since the gate charge reduction rate immediately after the turn-off initiation to which surge voltage becomes high most was made late, and reflux diode etc. carried out the turn-on, and it considered as the gate actuation which makes a gate charge reduction rate quick according to this invention as mentioned above after the surge voltage generating factor decreased, the switching operation in low switching loss and low surge voltage becomes possible. Moreover, even if a driver configuration becomes a little complicated, by adoption of a suitable driver configuration, drastic reduction of snubber circuits, as a result the formation of snubber loess are possible for it, and it becomes greatly advantageous as the whole equipment.

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] There are the following troubles in the above-mentioned cure.

[0009] Although surge voltage will fall if the trouble switching rate of (A) is made late, the time amount which switching takes becomes long. Although a problem shifts to cooling of a component since the increment in the switching time leads to the increment in the turn off power losses of a switching element (IGBT1), cooling of a component is important on a property and cannot make a switching rate slow recklessly.

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[0011] This invention aims at offering the gate drive circuit of the armature-voltage control form switching element which is easy circuitry and can carry out a turn-off in small loss and low surge voltage by having been made in view of the above-mentioned situation, and multiplexing a gate signal supply circuit.

[0012] Moreover, by ****ing the initial specialized circuit of a turn-off instead of duplex-izing of a gate signal supply circuit, this invention is comparatively easy circuitry and aims at offering the gate drive circuit of the armature-voltage control form switching element which can carry out a turn-off in small loss and low surge voltage.

MEANS

[Means for Solving the Problem] This invention prepares two or more gate signal supply circuits which supply alternatively the gate voltage for turn-ons, and the gate voltage for turn-ofves to the gate of an armature-voltage control form switching element through a switching circuit and gate resistance, and is characterized by having considered one as the actuation from the early stages of a turn-off, and considering others as the actuation after predetermined time on the occasion of a turn-off.

[0014] Moreover, this invention is set in the gate drive circuit of the armature-voltage control form switching element which supplies alternatively the gate voltage for turn-ons, and the gate voltage for turn-ofves to the gate of an armature-voltage control form switching element through a switching circuit and gate resistance. Prepare the initial specialized circuit of a turn-off which has a discharge way between the common terminal of a switching circuit, and Gnd level, and it faces at a turn-off. Only the initial specialized circuit of a turn-off is operated first, and it is characterized by performing turn-off actuation of a switching circuit, and off actuation of the initial specialized circuit of a turn-off after predetermined time.

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[0018] In addition, although the gate signal supply circuit was made into two circuits (duplex) with the above-mentioned operation gestalt, it can also multiplex in three or more circuits. In that case, if the number of circuits and the value of gate resistance are selected suitably, the gate charge reduction rate accommodation at the time of a fine turn-off is attained, and more effective switching operation (low switching loss and low surge voltage) can be expected.
[0019] Other operation gestalten of this invention are shown in drawing 3 . For IGBT and 2, as for the switching circuit for turn-on turn-off control, and 4, gate resistance and 3 are [one / the power source for turn-ons (electrical-potential-difference +Vcc) and 5] the power sources for turn-ofves (electrical potential difference - Vee) among drawing. The switching circuit 3 for turn-on turn-off control is considered as the configuration it connected transistors TR1 and TR2 to the serial, and connected gate resistance 2 at the node, and connected +Vcc connection driver DR1 and -Vee connection driver DR2 to the base, respectively. It is the initial specialized circuit of a turn-off, and the transistor TR3 turned on and turned off with this output constituted 6, the collector of a transistor TR3 is connected to gate resistance 2, and it has connected the emitter with the Gnd connection driver DR3 at the node (Gnd point) of the power source 4 for turn-ons, and the power source 5 for turn-ofves, respectively.
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[0024] Therefore, although a switching rate becomes slow by this operation gestalt under the effect of the period of the initial specialized circuit 6 of a turn-off of operation even if it can reduce surge voltage when gate resistance 2 is made into the same value, surge voltage can make a smaller value the part which can make late the switching rate immediately after the switching produced most, and gate resistance 2. In Vcc=Vee, gate resistance 2 can be made the value of abbreviation one half, and the increment in the switching time by actuation of the initial specialized circuit 6 of a turn-off is fully compensated with it in that case by reduction in the period of subsequent -Vee connection driver DR2 of operation.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The circuitry Fig. showing 1 operation gestalt of this invention.
[Drawing 2] For (a), with the explanatory view of operation when carrying out turn-off actuation only of the gate signal supply circuit in 1 operation gestalt, (b) is the circuit diagram showing a circuit electrical-potential-difference condition, and the representative circuit schematic seen from the IGBT side.
[Drawing 3] The circuitry Fig. showing other operation gestalten of this invention.
[Drawing 4] The circuit diagram for explaining the situation of operation when operating the initial specialized circuit of a turn-off in other operation gestalten.
[Drawing 5] The circuit diagram for explaining the situation of operation when operating -Vee connection driver in other operation gestalten.
[Drawing 6] The circuitry Fig. showing the conventional general gate circumference circuit.
[Drawing 7] The circuitry Fig. showing the gate drive circuit equivalent to the gate circumference circuit of drawing 6 .
[Drawing 8] The circuit diagram showing an example of a typical snubber circuit.
[Drawing 9] The circuit diagram showing other examples of a typical snubber circuit.
[Description of Notations]
1 -- IGBT
2, 2-1, 2-2 -- Gate resistance
3, 3-1, 3-2 -- Switching circuit for turn-on turn-off control
4 -- Power source for turn-ons
5 -- Power source for turn-ofves
6 -- Initial specialized circuit of a turn-off

TR1-TR3 -- Transistor
DR1-DR3 -- Driver